Miracle Ray - Ebwa
19/ENG05/072
Fluid Mechanics

(1) real $Q = 10 dm^3 min^{-1}$

7.00 $T = 12.5 Nm$

$Q_{real} = \frac{10 \times 10^{-3}}{60} = 1.67 \times 10^{-4} m^3 s^{-1}$

8.00 Pressure $= 12 bar = 12 \times 10^5 Nm^{-1}$

9.00 Speed $= 1500 rev min^{-1} = \frac{1500}{60} = 25 revs^{-1}$

10.00 nominal displacement $= 10 m^3 rev^{-1} \simeq 1 \times 10^{-5} m^3 rev^{-1}$

11.00 Q_{ideal} = nominal displacement × speed
$= 1 \times 10^{-5} \times 25$

12pm $= 2.5 \times 10^{-4} m^3 sec^{-1}$

- Volumetric efficiency $= \frac{1.67 \times 10^{-4}}{2.5 \times 10^{-4}} \times \frac{100}{1}$

1.00 $= 66.8\%$

2.00 fluid power $= Q.dp$
$= 1.67 \times 10^{-4} \times 12 \times 10^5$

3.00 $= 200.4 W$

- Shaft power $= T.\omega$

4.00 $\omega = 2\pi N = 2 \times \pi \times 25 = 157.08$

$\therefore$ Shaft power $= 12.5 \times 157.08 = 1963.5 W$

5.00 - Overall efficiency $= \frac{200.4}{1963.5} \times \frac{100}{1}$

6.00 $= 10.2\%$

7.00 (2) $Q = 35 dm^3 min^{-1} = \frac{35 \times 10^{-3}}{60} = 5.83 \times 10^{-4} m^3 s^{-1}$

8.00 $P = 100 bar = 1 \times 10^7 Nm^{-1}$

Efficiency $= 87\%$

fluid power $= Q.dp = 5.83 \times 10^{-4} \times 1 \times 10^7$
$= 5.83 \times 10^4 \simeq 6330 W$

Notes

Efficiency $= \frac{\text{fluid power}}{\text{shaft power}} \times \frac{100}{1}$

$\frac{87}{100} = \frac{5830}{S.P}$

$S.P = \frac{583000}{87} = 6705.75 W$

(3) displacement $= 50 cm^3 rev^{-1} \simeq 5 \times 10^{-5} m^3 rev^{-1}$

$P = 100 bar \simeq 1 \times 10^7 Nm^{-1}$

$S.P = 15 kW \simeq 15000 W$

$Q_{real} = 35 dm^3 min^{-1} \simeq \frac{35 \times 10^{-3}}{60} = 5.83 \times 10^{-4} m^3 s^{-1}$

Rotation $= 850 rpm \simeq \frac{850}{60} = 14.17 revs^{-1}$

fluid power $= Q.dp = 5.83 \times 10^{-4} \times 1 \times 10^7$
$= 5.83 \times 10^3 \simeq 5830 W$

$\therefore$ Overall efficiency $= \frac{5830}{15000} \times \frac{100}{1} = 38.86\%$

$Q_{ideal} = 5 \times 10^{-5} \times 14.17 = 70.8 \times 10^{-5} m^3 sec^{-1}$

$\therefore$ Volumetric efficiency $= \frac{5.83 \times 10^{-4}}{70.8 \times 10^{-5}} \times \frac{100}{1} = 82.34\%$

(4) $z = 2400 cm \simeq 24 m$

$Q = 13 Ls^{-1} \simeq 0.013 m^3 s^{-1}$

$V = 66 ms^{-1}$

$P = \rho g Q \left(\frac{P}{\rho g} + \frac{V^2}{2g} + z \right)$

$P = \frac{\rho Q V^2}{2g} + gQz + QP$

Pressure head $= 0$; $z = 0$

$P = \frac{\rho Q V^2}{2g} = \frac{1000 \times 0.013 \times 66^2}{2 \times 9.81}$

$= \frac{56628}{2} = 28314 W$

Power of jet $= 28314 W$

- Patm $= 0$; $V = 0$ $\therefore P = \rho g Q z$
$= 1000 \times 9.81 \times 0.013 \times 240$
$= 30607.2 W$ (power from reservoir)

- Power loss in transformer
$= 30607.2 - 28314 = 2293.2 W$

Head loss $= 2293.2 W$

$h = \frac{2293.2}{1000 \times 9.81 \times 0.013} = \frac{2093.2}{127.53} = 17.98 m$

- Efficiency $= \frac{28314}{30607.2} \times \frac{100}{1}$
$= 92.51\%$

January
M T W T F S S
* * 1 2 3 4 5
6 7 8 9 10 11 12
13 14 15 16 17 18 19
20 21 22 23 24 25 26
27 28 29 30 31

March
M T W T F S S
30 31 * * * * 1
2 3 4 5 6 7 8
9 10 11 12 13 14 15
16 17 18 19 20 21 22
23 24 25 26 27 28 29

(5) $X_{cl} = 0.87$

$z = 30{,}000\,cm \approx 300\,m$

$Q = 220\,ls^{-1} \approx 0.22\,m^3s^{-1}$

$V = 7\,ms^{-1}$

$P = \frac{\rho Q V^2}{2} = \frac{0.89 \times 1000 \times 0.22 \times 7^2}{2}$

$= 4797.1\,W$

$P = \rho g Q z$

$= 0.89 \times 1000 \times 9.81 \times 0.22 \times 3000$

$= 576239.4\,W$

Power loss $= 576239.4 - 4797.1$

$= 571442.3\,W$

$\therefore$ Head loss $= \frac{571442.3}{0.89 \times 1000 \times 9.81 \times 0.22} = 297.51\,m$

Efficiency $= \frac{4797.1}{571442.3} \times \frac{100}{1} = 0.83\%$

(6) $P = \rho g Q z$

$z = h = 20\,m$

$\rho = 1000$

$g = 9.81\,ms^{-2}$

$d = 10\,cm \approx 0.1\,m$

$A = \frac{\pi d^2}{4} = \frac{\pi \times 0.1^2}{4} = 7.85 \times 10^{-3}\,m^2$

$V^2 = U^2 - 2gh$

$0^2 = U^2 - 2 \times 9.81 \times 20$

$0^2 = U^2 - 392.4$

$392.4 = U^2$

$U = \sqrt{392.4}$

$= 19.81\,ms^{-1}$

Notes

$Q = VA$

$= 19.81 \times 7.85 \times 10^{-3} = 0.156\,m^3s^{-1}$

$\therefore P = \rho g Q z$

$= 1000 \times 9.81 \times 0.156 \times 20$

$= 30510.8\,W$

(7) $d_1 = 0.3\,m$; $A_1 = \frac{\pi \times 0.3^2}{4} = 0.707\,m^2$

$d_2 = 0.2\,m$; $A_2 = \frac{\pi \times 0.2^2}{4} = 0.0314\,m^2$

$C_d = 0.96$

$\Delta P_{gauge} = 19.62\,Nm^{-2}$

$\frac{mg}{V} = \rho g$

$\frac{19.62}{9.81} = \frac{\rho \times 9.81}{9.81}$

$\therefore \rho = 2\,kgm^{-2}$

$Q_1 = Q_2$

$V_1 = \frac{Q_1}{A_1}$, $V_2 = \frac{Q_2}{A_2}$

$V_1 = \frac{Q}{0.707}$, $V_2 = \frac{Q}{0.0314}$

manometer =

$P_1 - P_2 = \rho g (z_2 - R_p) + \rho_w g R_p - \rho_s g z$

$P_1 - P_2 = 19.62(z_2 - z_1) + 587.423$

Venturimeter =

$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$

$P_1 - P_2 = 19.62(z_2 - z_1) + 0.803 V_2^2$

$z_2 - z_1 = 0.06\,m$

$19.62(z_2 - z_1) + 587.423 = 19.62(z_2 - z_1) + 0.803 V_2^2$

$V_2 = \sqrt{587.423 \div 0.803} = \sqrt{731.54}$

$= 27.047\,ms^{-1}$

$Q_{ideal} = V_2 A_2 = 27.047 \times 0.0314 = 0.85\,m^3s^{-1}$

$Q_{real} = C_d \times Q_{ideal} = 0.96 \times 0.85 = 0.816\,m^3s^{-1}$

(8) $d_{throat} = 0.076\,m$, $A_t = \frac{\pi \times 0.076^2}{4} = 4.54 \times 10^{-3}\,m^2$

$d_{inlet} = 0.152\,m$, $A_v = \frac{\pi \times 0.152^2}{4} = 0.0181\,m^2$

relative density $= 0.8$

$z_1 - z_2 = 0.414$

$C_d = 0.97$

$Q_1 = Q_2$

$A_1 V_1 = A_2 V_2$

$V_1 = \frac{A_2 V_2}{A_1} = \frac{4.54 \times 10^{-3} \times V_2}{0.0181} = 0.251 V_2$

$\therefore$ for $P_1 = P_2$, $\rho = 800$

$\frac{P_1}{\rho g} - \frac{P_2}{\rho g} + \frac{V_1^2}{2g} + z_1 - \frac{V_2^2}{2g} + z_2$

$$z_1 - z_2 + \frac{V_1^2}{2g} = \frac{V_2^2}{2g}$$

7.00

$$0.914 + \frac{(0.251V_2)^2}{2\times 9.81} = \frac{V_2^2}{2\times 9.81}$$

8.00

$$0.914 = \frac{V_2^2 - (0.251V_2)^2}{19.62}$$

9.00

$$17.93 = V_2^2 - 0.063V_2^2$$

10.00

$$17.93 = 0.937V_2^2$$

$$V_2 = \sqrt{\frac{17.93}{0.937}} = 4.37ms^{-1}$$

11.00

$\therefore Q_{real} = C_d \times Q_{ideal}$

12pm

$$Q_{ideal} = 4.37 \times 4.57 \times 10^{-3}$$
$$= 0.0199m^3s^{-1}$$
$$Q_{real} = 0.97 \times 0.0199$$
$$= 0.0193m^3s^{-1}$$

$- P_1 - P_2 = 15170$

$$\left(\frac{P_1}{\rho g} + z_1\right) - \left(\frac{P_2}{\rho g} + z_2\right) = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

$$\frac{P_1 - P_2}{\rho g} + (z_1 - z_2) = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

$$\frac{15170}{850\times 9.81} + 0.914 = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

$$2.847 = \frac{(Q/A_2)^2 - (Q/A_1)^2}{2\times 9.81}$$

$$55.86 = \left(\frac{Q}{A_2}\right)^2 - \left(\frac{Q}{A_1}\right)^2$$

$$55.86 = Q^2\left(\frac{1}{A_2^2} - \frac{1}{A_1^2}\right)$$

$$55.86 = Q^2\left(\frac{1}{(9.57\times 10^{-3})^2} - \frac{1}{0.0181^2}\right)$$

$$55.86 = Q(48516.3 - 3052.4)$$

Notes

$$55.86 = Q(45463.9)$$

$$Q^2 = \frac{55.86}{45463.9} = 1.23\times 10^{-3}m^3s^{-1}$$

$$Q = 0.035m^3s^{-1}$$

(9) $d_1 = 300mm \simeq 0.3m$; $A_1 = 0.07069m^2$

$d_2 = 150mm \simeq 0.15m$; $A_2 = 0.0177m^2$

$Q = 40ls^{-1} \simeq 0.04m^3s^{-1}$

$z_1 = 10m$

$z_2 = 6m$

$P_1 = 400kNm^{-2}$

$P_2 = ?$

$$V_1 = \frac{Q}{A_1} = \frac{0.04}{0.07069} = 0.57ms^{-1}$$

$$V_2 = \frac{Q}{A_2} = \frac{0.04}{0.0177} = 2.26ms^{-1}$$

$$\frac{P_1}{\rho g} + z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + z_2 + \frac{V_2^2}{2g}$$

$$\frac{P_1}{\rho g} + (z_1 - z_2) + \left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g}\right) = \frac{P_2}{\rho g}$$

$$\rho g\left(\frac{P_1}{\rho g} + (z_1 - z_2) + \left(\frac{V_1^2}{2g} - \frac{V_2^2}{2g}\right)\right) = P_2$$

$$1000\times 9.81\left(\frac{400kN}{9.81kN} + (10-6) + \frac{0.57^2 - 2.26^2}{2\times 9.81}\right)$$

$$9.81kN(40.77 + 4 - 0.2438)$$

$\therefore P_2 = 436.74kN$

(10) manometer reading $= 170mm \simeq 0.17m$

$X_{mercury} = 13.6$ $X_{kerosene} = 1.026$

$y = 0.17$

for h ; $y\left(\frac{S_h L}{S L} - 1\right) = 0.17\left(\frac{13.6}{1.026} - 1\right)$

$= 0.17 \times 12.255 = 2.08m$

Recall that ; $V = \sqrt{2gh}$

$\therefore V = \sqrt{2\times 9.81 \times 2.08}$

$= \sqrt{40.81}$

$= 6.39ms^{-1}$